INTRODUCTION

Traffic signal equipment, ITS equipment and software are constantly changing due to electronics, communications hardware and emerging standards. Therefore, on most projects, the Standard Specifications will be supplemented by the plans and Project Special Provisions. The Resident Engineer should thoroughly review the Project Special Provisions to identify the specific requirements of the contract.

DIVISION 17
SIGNALS AND INTELLIGENT TRANSPORTATION SYSTEMS

SECTION 1700
GENERAL REQUIREMENTS

1700-1 DESCRIPTION

Work covered under Division 17 includes not only traffic signals, but also various communication devices and hardware necessary to interconnect the traffic signals and intelligent transportation system (ITS) components. Work of this nature is extremely specialized. All components of these systems are dependent on each other and must be installed correctly to provide for safe and orderly movement of traffic. Improper installation of equipment can initially appear acceptable to someone who is not familiar with the operation of these types of systems. But, improperly installed equipment will eventually lead to significant problems either during the life of the project or after the project has been accepted. These problems directly impact the safe and efficient flow of traffic through the work zone or along a segment of roadway causing motorists undue frustration, unnecessary delay, and potentially dangerous roadway conditions. For purposes of this document and of the Standard Specifications, all references to "equipment" imply ITS and Traffic Signal hardware, components, and materials.

If questions arise regarding the plans or specification for these systems, contact should be made through the Resident Engineer's office directly to the Engineer in charge of the plans in the Transportation Mobility and Safety Division. The Engineer in charge of the plans will typically be the NCDOT representative listed on the project cover sheet.

Given the specialized nature of these systems, an Intersection Inspection Checklist (See Appendix D) will be presented to the Contractor and signal Subcontractor at the Preconstruction Meeting. The Contractor should incorporate the Intersection Checklist into their quality control program and be expected to correct deficiencies prior to final inspection.

1700-2 MATERIALS

Material specifications, including catalog cut sheet submittal requirements and equipment warranties, are generally covered under Sections 1091 and 1098 and the Project Special Provisions.

Always check materials received on a project against approved catalog cuts, shop drawings, or QPL submittal. These materials typically require a Type 3 material certification.

Ensure:

- That the Department is provided a license to duplicate all programmable devices in the equipment for maintenance and software upgrades.
- One set of manuals, electrical schematic diagrams, and cabinet wiring diagrams are provided for each control equipment cabinet and the equipment in the cabinet.
- Operator's manuals are provided containing detailed operating instructions for each different type or model of equipment.
- Warranties are transferred to NCDOT.
- Material Certifications are provided.

QUALIFIED PRODUCTS LIST INSTRUCTIONS

ITS and signals materials are to be submitted to the ITS & Signals Unit for approval. Submit to the State ITS and Signals Engineer.

The Department has an ITS and Signals Qualified Products List (QPL) available for the Contractor's use. The QPL web site is:

https://connect.ncdot.gov/resources/safety/Pages/default.aspx
/

Certain signal and ITS equipment, material, and hardware are required to be pre-approved on the ITS and Signals QPL by the date of installation on the project. Equipment, material, and hardware not pre-approved when required will not be allowed for use on the project.

Equipment may be submitted in the following forms:

For Contractor-furnished equipment required to be listed on the QPL, furnish 3 copies of the QPL equipment submittal list in the format below.

EQUIPMENT/ MATERIALS LIST FORMAT

Bid Line Item No.	QPL Group.	Construction Item Number and Description	Manufacturer Product Number Assigned by NCDOT	Manufacturer	Manufacturer Model Number or Other Designation	Approved Construction Applications
168	WIR	WLI14-2CIMSA50-2R2LAY-2012-1098-9 Wire, Lead-in 14-2 Copper IMSA 50-2 Ripcord 2"	COLWLI14-2CIMSA50-2R2LAY	Coleman/CCI	513928	1726

Equipment required to be listed on the QPL may also be submitted by e-mail. A feature has been added to the on-line QPL web page to reduce handling time and paperwork. The web site allows the Contractor to develop a list of items for submittal for projects utilizing the 2012 Standard Specifications for Roads and Structures or previous specifications. By searching and selecting particular items desired for submittal, a list can be generated from the web site. Upon completion of the list with all the appropriate information (Bid Line Item Number, TIP Number and Project Number), an MS Excel (.xls) file of the submittal list can be generated. This file can be saved on the user's computer and later e-mailed directly to the Resident Engineer, appropriate Regional Signals Engineer, and Signal Equipment Applications Project Engineer. The e-mail method can also be used in the event the originally approved equipment or material is not available to the Contractor because of unexpected shortages during construction. A recommendation from the ITS and Signals Unit will be returned to the Resident Engineer by e-mail for further action.

For Contractor-furnished equipment that is not required to be on the QPL, the Contractor shall furnish 3 copies of catalog cuts of the equipment being submitted for approval. The proposed equipment shall be identified on the catalog cuts. Equipment catalog cuts submitted must contain the material description, brand name, manufacturer's address and telephone number, stock number, size, identifying trademark or symbol, and other appropriate ratings.

Equipment shall not be fabricated or ordered until receipt of the Engineer's approval. If the Contractor elects to fabricate or order equipment prior to approval, the Contractor does so at his own risk.

Guide to using the 2012 ITS and Signals QPL via the Internet

The ITS and Signals Qualified Products List (QPL) contains traffic signal and ITS equipment and material standards that are approved for use on contract projects on the North Carolina State Highway System. Although this list is generally valid for NCDOT projects, the Project Special Provisions may have additional requirements and be more restrictive than this list.

Equipment, materials, and hardware not on the 2012 ITS and Signals QPL will not be allowed for use on projects referencing the 2012 Standard Specifications for Roads and Structures unless otherwise allowed by the Project Special Provisions for the specific project.

Products on the 2012 ITS and Signals QPL are based on the Materials section (Sections 1082, 1091 and 1098 of Materials - Division 10) and the Signals and Intelligent Transportation Systems Construction Methods section (Division 17) of the 2012 Standard Specifications for Roads and Structures and Project Special Provisions.

The instructions below provide a step-by-step guide on how to view and use the ITS and Signals Qualified Products List information service.

1. Via your Internet Service Provider, log on to the Internet. Open the following address to go directly to the web site for the QPL:
   https://connect.ncdot.gov/resources/safety/Pages/default.aspx
2. There are several ways to access information on qualified equipment and materials. The options by which the user can obtain the desired information on the web site are listed below:
   - The first method involves viewing the entire QPL. This method displays the entire list in a format that allows the user to scroll through and find the equipment or material construction item of choice. This method may be achieved by viewing the online version and clicking the "Search" button without choosing a category.
   - A second method of accessing information from the QPL is by viewing the online version and selecting a construction group from the “Group” Category, then click “Search”. A list of all items in that group will be displayed. The user can scroll through and find the equipment or material of choice.
   - A third method of accessing the QPL allows the user to view all products a single manufacturer has on the QPL. By viewing the online version, selecting a manufacturer from the Manufacturer Category, and clicking “Search”, a list will be displayed of all products of the selected manufacturer.
   - The fourth method of accessing information from the QPL is by viewing the online version and selecting a construction application from the “Approved Applications” Category, then click “Search”. A list of all items used in that construction application will be displayed. The user can scroll through and find the equipment or material of choice. This category represents the specific construction method(s) in Division 17 of the 2012 Standard Specifications to which the product can be applied.
   - A fifth method of accessing the QPL allows the user to narrow their search by selecting criteria from 2 or 3 of the above methods at the same time. After clicking "Search," the user will retrieve a more specific list of products.
   - A sixth method of accessing the QPL allows the user to download the entire QPL listing in file form as a Microsoft Excel spreadsheet file. The Microsoft Excel spreadsheet file option appears as a link (Downloadable Version) on the main page.

Users should be aware that the list may be updated during the first week of the month. The last update of the online QPL database can be seen in the search frame.

Should you have any questions regarding the above procedure, please contact the Signal Equipment Applications Project Engineer.

1700-3 CONSTRUCTION METHODS

(A) GENERAL

To ensure the Contractor is not held liable for pre-existing conditions, the Contractor is required to report any defective equipment prior to beginning any signal work.

It is not intended for the Contractor to be responsible for the traffic signals immediately upon being awarded the project. This is because the Contractor may not have proper traffic signal cabinets and controllers to maintain the existing equipment. Except for damages and malfunctions caused by the Contractor's work activities, the Contractor should not be held responsible for pre-existing conditions that were reported to the Engineer before starting traffic signal work at the specific intersection. The Contractor will assume responsibility for all maintenance and emergency services once traffic signal work has begun at the specific intersection, and for all damages and malfunctions caused either directly or indirectly by the Contractor's work activities.

Note also that the Contractor is responsible for repair or replacement of material and equipment that is damaged by the Contractor or the Subcontractor due to construction activities that may have occurred prior to beginning signal work. The Contractor is liable for repair or replacement of the damaged material and equipment (Refer to Section 104-10 in the Standard Specifications). Repairs should be coordinated with the Resident Engineer. The Resident Engineer should also notify the Division Traffic Engineer of repairs to be made by the Contractor.

Although signal work may not have started on a project, repair of damaged equipment should begin within 4 hours of notification and be completed within 8 hours. In the event the Contractor fails to perform in accordance with the plans and specifications within the time frame specified, the Department reserves the right to perform the maintenance and emergency service necessary to assure continuous traffic signal operation. Further, all expenses incurred by the Department in implementing this option will be deducted from the payment due the Contractor, plus liquidated damages per occasion, per day, or any portion thereof, until corrected. The liquidated damages are due to increased public hazard resulting from the malfunction. The Engineer should discuss these expectations at the Preconstruction Meeting with the Contractor, signal Subcontractor (if any), and Division Traffic Engineer. Note that grading operations could damage existing signal loops and lead-in cable.

Prior to beginning any construction work around a signalized intersection including clearing, grubbing, grading, and widening operations, the Contractor should ensure all utilities have been located. Typically, the Contractor will use utility location services such as NC One Call. This includes power, telephone, gas, cable television, water, and sewer. **Existing traffic signal communications cable, traffic signal cable, detector loops, lead-in cable, and other underground cable are not located by NC One Call.** The Contractor should contact the signal Subcontractor or the Division Traffic Engineer to have these located.

The Contractor is required to have on standby an IMSA certified, or equivalent, Level II traffic qualified signal technician for supervision and emergency maintenance whenever work is performed on traffic signal controller cabinets and traffic signal controller cabinet foundations.

(B) REGULATIONS AND CODES

Questions pertaining to the referenced electrical regulations and codes should be directed to the Signals Management Engineer staffed to the Transportation Mobility and Safety Division.

(C) UTILITY SERVICES

The Department is responsible for payment of monthly utility charges to the utility company. However, the Contractor is responsible for arranging all necessary utility services including power, telecommunications, and telephone where needed. The Contractor will be responsible for all expenses associated with utility installation costs, hookups, etc.

(D) MAINTENANCE AND REPAIR OF MATERIAL

- Once responsibility for the traffic signals has been assumed by the Contractor, the Contractor is responsible for repair and maintenance of all equipment failures and malfunctions. The Contractor is required to begin these repairs within four hours of being notified. Repairs should be completed within eight hours.
- The Technician should document in the construction diary the time the Contractor was notified of the need for repairs.
- For failed detection, detection must be restored and the Contractor should not be allowed to operate the traffic signal in a pre-timed fashion through recall functions for an extended time. Doing so will cause the traffic signal to operate in an extremely inefficient manner causing significant delays and traffic backups. The Contractor should begin repairs within four hours of being notified and be completed within 8 hours.
- The Contractor is required to perform maintenance (testing) on all traffic signal conflict monitors every 12 months for the life of the project. Testing should be performed per the manufacturer's recommendation. Two copies of test results must be provided: one for the Engineer and one for the traffic signal cabinet.
- Responsibility for repairing and maintaining the traffic signal is transferred back to the Department upon completion of the 30-day observation period and acceptance of the project.
- **The Resident Engineer should notify the Division Traffic Engineer of acceptance of the project.**

(E) INSPECTIONS

During the course of the project, the Department may need to access the Contractor's equipment to perform preventative maintenance and other necessary inspections. The Contractor should be present when these activities occur. On large signal system projects, the Contractor may be required to perform annual inspections. The Contractor must submit the test results to the Resident Engineer.

(F) REMOVAL OF EXISTING EQUIPMENT AND MATERIAL

- The Contractor is to assume ownership of miscellaneous traffic signal hardware and is responsible for proper disposal.
- The Department retains ownership of major components of existing traffic signals such as controllers, cabinets, detector units, conflict monitors, signal heads, railroad and emergency

vehicle preemption components. The Contractor is responsible for returning these major components to the Division Traffic Engineer.

- The Department retains ownership of the major components of existing temporary signal equipment.

(G) RAILROAD PREEMPTION

- The Contractor is responsible for coordinating installation of any required railroad preemption with the railroad company. The Division Traffic Engineer should be notified of all work done.
- **Do not allow the traffic signal to be placed into operation until all necessary railroad-highway crossing devices are operating properly and are interconnected to the traffic signal. Contact the Division Traffic Engineer before the traffic signal is placed into operation.**
- The Contractor should complete and submit the Preemption Test Procedure Checklist. The form may be obtained electronically at the following web address:

https://connect.ncdot.gov/resources/safety/Pages/default.aspx

- For assistance with railroad-highway crossing devices, the Engineering and Safety Branch of the Rail Division may be contacted at (919) 715-8803.
- Do not place locations with railroad preemption into late night flash operation.

(H) VEHICLE PREEMPTION SYSTEMS

These systems generally are used to provide right-of-way to an emergency vehicle such as police, fire, rescue, and EMS service providers. Vehicle preemption systems may utilize a broad range of technologies ranging from a push button located in a fire and rescue building, to siren or strobe light actuated sensors placed overhead at the signalized intersection.

- The Contractor is responsible for contacting local authorities to coordinate installation of any required vehicle preemption systems.
- The Contractor should complete and submit the Preemption Test Procedure Checklist. The form may be obtained electronically at the following web address:

https://connect.ncdot.gov/resources/safety/Pages/default.aspx

(I) TIMING OF SIGNALS

Timing of traffic signals significantly impacts the flow of traffic. The Contractor is responsible for implementation of timing values shown on the signal plans and for reinstalling any existing signal system coordination values. Contractor may adjust values as identified on the signal plan to accommodate actual field conditions. However, in no case should the yellow clearance, red clearance, or flashing Don't Walk values be modified from that shown on the signal plan without written approval from the Engineer in charge of the plans.

The Department retains the right to have its own personnel make timing changes to the traffic signals or to have the Contractor make these changes. The Resident Engineer will be contacted prior to the changes being made by the Department's personnel.

For assistance with timing related issues, either the Division Traffic Engineer or the Engineer in charge of the plans may be contacted. However, an inspection of all traffic signal equipment for proper operation should be performed prior to seeking assistance with timing issues. Frequently, problems are identified as being associated with malfunctioning equipment such as failed detection loops rather than timing issues.

(J) WIRE AND CABLE

Cable and wire from several manufacturers may be approved for the project. Check manufacturer recommendations to ensure lubricants are approved for the wire and cable insulation. Splices shall not be permitted inside the conduit system.

(K) GROUNDING

Grounding electrode resistance should also be recorded on the "Inductive Detection Loops & Grounding Test Results" form (see Appendix A). The completed original form should be placed in the controller cabinet and a copy given to the Resident Engineer. The form may be obtained electronically at the following web address:
https://connect.ncdot.gov/resources/safety/Pages/default.aspx

(L) ELECTRICAL BONDING

Proper grounding and bonding provide for a safe electrical installation for DOT personnel, Contractor personnel and the general public. Metal traffic signal poles, vehicular and pedestrian pedestals and metal junction box covers must be bonded with a minimum 14-AWG copper conductor. A ground rod installed at the metal pole cannot serve as the ground-fault current path.

(M) TRAFFIC SIGNAL ACTIVATION

The traffic signal must be inspected and authorized for activation to ensure it will operate safely and efficiently. The Division Traffic Engineer should be notified of scheduled activation.

(N) TEMPORARY TRAFFIC SIGNAL INSTALLATIONS

This is for signals that are installed during construction and removed prior to final acceptance of the project.

- Areas impacted by the temporary signal installation are to be restored to like new conditions.
- Contractor is responsible for getting the intersection ready for sign control including installation of regulatory signs.
- Signal must be placed in flash immediately when the signs are uncovered. Otherwise, an unsafe condition may result whereby the signal indications conflict with the signs.
- Make sure flashing operation does not conflict with sign displays (i.e.: flashing yellow signals on a stop signed approach).
- Signal must operate in flash for a period of time as directed by the Engineer (typically seven days) to allow motorists to gain familiarity with the intersection operation.

SECTION 1705
SIGNAL HEADS

This section covers the requirements for signal heads including vehicle signal heads and pedestrian signal heads. Signal heads are the most visible component of the traffic signal installation. As such, signal heads should be field adjusted by the Contractor to obtain optimum visibility for the motorist.

The Technician should ensure:

- LED modules are oriented in the correct position within the signal head section.
- Signal head tabs firmly hold LED module in place.
- All signal heads, span wire hanging hardware, and side of pole mounting hardware are painted yellow unless otherwise required by the Project Special Provisions.
- Vehicle signal head clearance is between 16.5 feet to bottom of signal head or 25.6 feet to top of signal head from the highest point of the roadway unless between 40 and 53 feet from stopbar (stop line) as shown in Figure 1705-1 in the 2012 Standard Specifications.
- Pushbutton or accessible pedestrian signal is mounted between 3.5 and 4.0 feet above the adjacent pedestrian travelway.
- Pedestrian signal heads are mounted between 7 and 10 feet above sidewalk level.
- Vehicle signal heads are not placed closer than 40 feet to the stopbar, with the exception of a supplemental nearside head, and no farther than 180 feet without a nearside head.
- Verify visibility and clarity of the signal heads by observing each approach. Notify the Engineer if any visibility issues are identified.
- Do not allow the Contractor to significantly vary from what is shown on the plans for any vehicular signal heads, pedestrian signal heads, and pedestrian pushbuttons without first discussing the variations with the Resident Engineer and/or the Regional Signals Engineer responsible for that area of the State.
- Refer to Roadway Standard Drawings 1705.01 and 1705.02.

SECTION 1706
BACKPLATES

If it is determined backplates may be needed and they are not shown on the plan, the Technician should coordinate with the Division Traffic Engineer and the engineer in charge of the plans to resolve the need.

SECTION 1710
MESSENGER CABLE

- Messenger cable is synonymous with spanwire.
- The Technician should ensure proper size for the application, 3/8 inch for messenger cable supporting vehicle signal heads and signs, and 1/4 inch for messenger cable supporting only cables (i.e. fiber optic, lead-in, or copper communication cable).
- Messenger cable shall be bonded and grounded. Take special note of any requirements shown on Communication Cable & Conduit Routing Plans.

SECTION 1715
UNDERGROUND CABLE INSTALLATION

- Minimum trench depth for underground conduit is typically 30 inches below finished grade or 6" below roadway sub-base, whichever is deeper. However, if the conduit is installed prior to the final traffic signal configuration, it may need to be buried deeper.
- If ditches are present, conduit should be installed 4 feet below the ditch line (minimum).
- If tracer wire is being installed, detectable marker tape is not needed; plain marker tape (4 inch) may be substituted.
- All installed conduit systems must be mandrel tested to ensure conduit has not been damaged. If damage has occurred, the entire length of conduit must be replaced.
- Refer to Roadway Standard Drawing 1715.01.

SECTION 1716
JUNCTION BOXES

- Ensure junction box cover is not cracked or broken during delivery, installation, or construction.
- Junction Boxes should be set flush with grade.
- Ensure the cover is bolted to the base.
- Standard junction boxes should not be substituted in place of over-sized, heavy-duty junction boxes.
- Ensure conduit at the point where it enters the working area of the standard junction box is a minimum of eight inches from the top of the box.
- Ensure conduit at the point where it enters the working area of the over-sized, heavy-duty junction box is a minimum of 20 inches from the top of the box. Conduit should enter the working space of the junction box at a 45° angle to facilitate the minimum bending radius of fiber optic cable within the junction box.
- Locations of junction boxes may be field adjusted.
- Refer to Roadway Standard Drawing 1716.01.
- The Contractor must provide coordinate information for all junction boxes and equipment cabinets installed or used on the project. A digital copy and hard copy of this information in the spreadsheet provided by the Department must be furnished to the Engineer.

SECTION 1720
WOOD POLES

- Poles should not be installed closer than six feet behind face of curb or 10 feet from edge of travelway. Ensure poles are long enough to maintain the minimum required clearances above the roadway, obstructions and railroad tracks.
- Check for underground and overhead utility conflicts. Contact the Engineer in charge of the plans if a readjustment is necessary.
- Ensure marking and code letters are burn-branded on the wood pole or printed on attached metal tag. Acceptable code letter for species and preservatives are: (Species-DF, SPPreservatives-SC, SJ, SK, PA, PC)
- Refer to Roadway Standard Drawings 1720.01.

SECTION 1721
GUY ASSEMBLIES

- Size of guy cable shall be the same size as the largest sized messenger cable to be guyed.
- Guy assemblies shall be bonded and grounded.
- Refer to Roadway Standard Drawings 1721.01.

SECTION 1722
RISER ASSEMBLIES

- Make sure the appropriate number of risers are installed to ensure proper separation of wires.
- Non-metallic risers are not allowed.
- Maintain a 10" minimum and 18" maximum offset from signal messenger to the top of riser.
- On utility-owned poles, maintain a minimum 40" offset from electrical utility's power conductors to top of riser and riser attachment fittings.
- Install condulets on risers for lead-in cable, railroad preempt interconnection cables and signal pedestals.
- All risers shall be bonded and grounded. A new grounding system must be installed if existing poles do not have a grounding system.
- Take special note of any requirements shown on Communication Cable & Conduit Routing Plans.

SECTION 1725
INDUCTIVE DETECTION LOOPS

- **For failed detection, detection should be restored and the Contractor should not be allowed to operate the traffic signal in a pre-timed fashion through recall functions for an extended time. Doing so will cause the traffic signal to operate in an extremely inefficient manner causing significant delays and traffic backups. The Contractor should begin repairs within 4 hours of being notified and they should be completed within 8 hours.**
- **THE ENGINEER SHOULD WITNESS ALL LOOP INSTALLATIONS.** This should be stressed to the Contractor at the Preconstruction Conference.
- Loops should be installed prior to the last layer of asphalt.
- On unmarked pavement, pre-mark locations of stop lines and lane lines before locating loops.
- Do not allow installation of loops during inclement weather (i.e. rain, ice, and snow).
- The Contractor should pre-mark the locations of all inductive detection loops, and receive approval of these locations from the engineer prior to saw cutting. Loop placement should be coordinated with pavement markings.
- Prior to sealing the loop conductors, the Contractor is required to test the impedance of the inductive loop wire to ground. A reading of at least 100 megohms is required. Loop testing results should be recorded on the "Inductive Detection Loops & Grounding Test Results" form (see Appendix A). The completed original form should be placed in the controller cabinet and a copy given to the Resident Engineer. The form may be obtained electronically at the following web address:
- https://connect.ncdot.gov/resources/safety/Pages/default.aspx

- Between where loop conductor pairs leave saw cut in pavement and junction boxes, twist loop conductor pairs a minimum of 5 turns per foot.
- Refer to Roadway Standard Drawings 1725.01.

SECTION 1726
LEAD-IN CABLE

- If new or existing lead-in cable is cut at any time it must be replaced.
- Ensure that splicing of lead-in-cable is done in junction boxes or condulets on poles.
- During construction, lead-in may be rerouted to accommodate field conditions.
- Temporary lead-in cable is typically buried at 12 inches. However, if the cable is installed prior to the final traffic signal configuration, it may need to be buried deeper.
- Ensure splicing is soldered and environmentally sealed.

SECTION 1730
FIBER-OPTIC CABLE

The work covered by this section involves the installation of fiber optic communications cable for the purpose of establishing a communications medium between one or more electronic devices (i.e., signal controller, dynamic message signs, closed circuit television camera, and operations centers). Refer to Roadway Standard Drawings numbered 1715.01 and 1730.01.

1730-3 CONSTRUCTION METHODS

(A) GENERAL

This section explains basic requirements necessary for installing communications cable.

- Optical Time Domain Reflectometer (OTDR) readings are obtained by attaching an electronic piece of equipment to the individual fibers, which injects an optical/light signal onto the fiber itself. Even though fiber is one of the best mediums for transmitting information, it is not impervious to impurities that would cause the optical/light signal to be degraded over a length of cable. Degradation of the optical/light signal occurs due to mechanical coupling, fusion splicing, and general impurities that are present due the manufacturing process. The OTDR tests provide data in the form of attenuation readings that ensures the fibers being used are adequate.
- Fiber optic cable is usually made from glass. Due to the characteristic make-up of the fiber, it is flexible and can be bent to some degree without breaking. If fibers are bent more than the minimum bending radius allowed by the manufacturer, it will damage the fiber. Should this occur, it would be discovered when the OTDR tests are performed.
- The Department requires that fiber-optic communications cable DOES NOT share a conduit/riser with any other cables. Ensure this rule is strictly followed during the construction process.

- OTDR tests should be performed before installation and again after installation. The Contractor must furnish the cable manufacturer's OTDR testing data for each reel of cable upon request. Refer to Section 1731-3(G) for required OTDR testing requirements.

(B) AERIAL INSTALLATION

- When installing any overhead cables on joint use utility poles, it must be installed in accordance with the requirements of the National Electrical Safety Code (NESC) and any other codes or ordinances adopted by the various utility companies. Reference "MINIMUM UTILITY CLEARANCE REQUIREMENTS" (see Appendix B) for general attachment guidelines and additional information.
- The Communications Cable and Conduit Routing Plans show the Contractor how to install the communications cable.
- The Resident Engineer should review the plans to ensure that the communications cable is being installed correctly.
- Review the plans to ensure spare cable is installed. The spare cable is not to be used for the Contractor's splicing and termination.

(C) UNDERGROUND INSTALLATION

- Prior to performing any underground work, State law requires the Contractor to notify the NC One Call Center (1-800-632-4949) before digging. Also contact the Division Traffic Engineer to locate existing signal or ITS facilities.
- Review the plans to ensure spare cable is installed in the junction boxes and cabinets. The spare cable is not to be used for the Contractor's splicing and termination.

(D) INSTALLATION OF DROP CABLE ASSEMBLY

- Drop cable is cable used to complete a connection between a splice location, such as an aerial splice enclosure and an adjacent electronic device. In general, this section of cable is identical to the fiber optic cable with the exception of having a fewer number of individual fibers.
- Refer to Roadway Standard Drawing 1730.01.

SECTION 1731
FIBER-OPTIC SPLICE CENTERS

1731-1 DESCRIPTION

This section identifies the different type of splice enclosures needed to terminate the fiber optic cable so that it can be connected to an electronic device or connected to other fibers. There are 2 types of splice centers we use; they are 1) Interconnect Center, 2) Splice Enclosures.

Reference "INTERCONNECT CENTERS AND SPLICE ENCLOSURES" (see Appendix C) for additional information.

1) Interconnect Center

- The interconnect center is usually placed in either an equipment cabinet or in a building where the fiber optic cable is to be terminated. The interconnect center consists of a box, splice trays, fiber pigtails, and a patch panel. The splice tray protects the fiber once it is stripped out of its outer jacket and buffer tube. The fibers are spliced inside the splice tray using a fusion splicing method and are arranged so they are easily inspected.
- Once the fiber leaves the splice tray it is either routed to an outgoing fiber going to another downstream electronic device or spliced to a pigtail. The pigtail is another link of fiber (approximately 6 ft long) that provides a connection from the incoming fiber to the backside of the patch panel.
- A jumper is connected to the pigtail on the front side of the patch panel. The jumper has connectors on each end. One end connects to the patch panel and the other end connects to an electronic device.

2) Splice Enclosure

- The splice enclosure is like the interconnect center described above. It is an enclosure usually made out of a polymer type material that, once closed, forms a weather tight seal. This enclosure contains splice trays but no patch panels. The splice enclosure is used to break out the individual fibers so that they can be connected to other fibers and routed in different directions. A splice enclosure can be installed aerially or underground in a junction box.

1731-3 CONSTRUCTION METHODS

(B) WORKMANSHIP

This article of the Specifications gives detailed instructions for splicing of fiber optic cable. The Contractor must take a digital photograph of the splice tray that shows the final workmanship. "Workmanship Identification Information" must be visible in the photograph. Digital copies of each photograph must be submitted on a compact disk.

(C) TERMINATION AND SPLICING WITHIN INTERCONNECT CENTER

Ensure:

- Fibers are spliced or terminated as required on the Fiber Optic Splice Plans.
- All fiber connections are labeled to identify their termination or origin points.

(E) TERMINATION AND SPLICING WITHIN AERIAL SPLICING ENCLOSURE

Ensure:

- Fibers are spliced or terminated as required on the Fiber Optic Splice Plans.
- All fiber connections are labeled to identify their termination or origin points.

(G) TESTING

Ensure:

- The Contractor performs a bi-directional OTDR test on fibers (including unused spares).
- The Contractor tests each launch cable and provides test results before use.
- The Contractor provides plots of each splice test.

- The Contractor provides 2 hard copies of the OTDR trace results and a compact disc containing the OTDR trace test results along with digital photographs showing workmanship for each splice.
- The Contractor provides 2 copies of the software needed to view OTDR traces electronically.
- The Division forwards a copy of the test results and compact disc to the ITS and Signals Unit for inspection and review.

SECTION 1732
FIBER-OPTIC TRANSCEIVERS

Fiber Optic Transceivers are devices used to convert the optical/light signal being generated through the fiber optic cable to an electronic signal and vice versa. The electronic signal is sent to an electronic or central office device, (i.e., traffic signal controller, CCTV camera unit, dynamic message sign, computer workstation, etc.), where it is used to communicate with the device.

The transceiver is connected to the fiber-optic splice center. Reference "INTERCONNECT CENTERS AND SPLICE ENCLOSURES" (see Appendix C) for additional information.

1732-3 CONSTRUCTION METHODS

Ensure:

- The transceivers are secured in the cabinet so that they cannot accidentally be pulled off and accidentally break the fiber jumpers.
- The transceiver's power supply module is connected to the receptacle circuit located on the rear of the Power Distribution Assembly (Type 170 cabinets) in the cabinet and not into the GFCI Receptacle. The GFCI Receptacle is a convenience outlet to be used by the Technician when working on the cabinet and can trip causing the transceiver to be inoperable.

SECTION 1733
DELINEATOR MARKERS

Delineator markers are used to identify that a communications cable is installed underground in the general vicinity of the delineator marker. If you line up two delineator markers in the field there should be some type of communications cable buried in the ground between the two posts/markers.

- Do not place delineator markers in aesthetically sensitive areas.
- The location of delineator markers may be field adjusted.

SECTION 1734
REMOVE EXISTING COMMUNICATIONS CABLE

On some projects, the Contractor will be required to remove existing aerial or underground communications cable. This will also include all pole mounting hardware and junction boxes if required by the plans. The Contractor should not remove any existing communications cable or messenger cable unless identified by the plans. In some instances, the plans will detail the new communications cable to be overlashed to the existing communications cable or messenger cable.

SECTION 1735
CABLE TRANSFERS

During the course of the project, the pole owner may require the communications cable to be relocated to a new pole. The communications cable should be relocated by the Contractor only. Should the relocation require extensive work such as moving across the roadway, a supplemental agreement may be necessary. Any additional cable or splices necessary are not included in the Cable Transfer pay item.

SECTION 1736
SPREAD SPECTRUM RADIO

The work covered by this section involves the installation of Spread Spectrum Radios for the purpose of establishing a communications medium between one or more electronic devices (i.e., signal controller, dynamic message signs, and operations centers).

A Spread Spectrum Radio system consists of a radio modem connected to an antenna via a length of coaxial cable.

Connected in line with the coaxial cable is a Lightning Arrestor which is designed to divert a high voltage surge away from the radio's electronics. Additionally, installed just prior to the antenna is a "Grounding Kit" which also helps to divert unwanted voltage away from the radio's electronics. The Grounding Kit is connected directly to the coaxial cable's internal braided shield or foil shield and has a length of copper cable that attaches to the copper ground wire installed along the side of a wood pole (pole ground).

Antennas are used to propagate the electromagnetic radio wave (radio signal) over the air waves. Antennas fall into two (2) categories 1) Yagi Antennas and 2) Omni Directional Antennas.

Yagi Antennas have a central member with various multiple length cross bars attached at different points along the central member (Much like television antennas installed outside on homes for TV reception). Yagi Antennas can be installed with the cross members being pointed up and down (Vertically Polarized) or left to right (Horizontally Polarized).

Omni Directional Antennas consist of a single member usually covered by white PVC material. The Omni Directional Antenna can only be installed in one direction, straight up and down (Vertically Polarized).

During construction ensure:

- The Wireless Radio is secured in the cabinet so that they cannot accidentally be pulled off.
- The Wireless radio's power supply module is connected to the receptacle circuit located on the rear of the Power Distribution Assembly (Type 170 cabinets) in the cabinet and not into the GFCI Receptacle. The GFCI Receptacle is a convenience outlet to be used by the Technician when working on the cabinet and can trip causing the transceiver to be inoperable.
- Ensure that a coaxial cable is installed between the RF port on the wireless radio to a lightning Arrestor. Ensure the lightning Arrestor is bonded to the shell of the Controller Cabinet.
- Ensure that a section of Coaxial Cable runs from the Lightning Arrestor to the Antenna mounted on the pole.

- Ensure that the Grounding Kit is installed just prior to the antenna and that the pigtail (copper cable) off of the Grounding Kit is connected to the copper ground wire installed along the side of a wood pole (pole ground).
- Program all Wireless Radio(s) with correct drivers and address #'s for system deployment. Ensure Master radio is reprogrammed to look for all radios in the system.

ANTENNA ALIGNMENT (Indicated on the Communications Plans)

- Omni Antennas are always installed vertically polarized (up and down)
- Yagi Antennas can be installed either vertically polarized (cross members point up and down) or horizontally polarized (cross members point left and right).
- Omni Antennas can communicate with both Omni Antennas and Yagi Antennas. However, if communications is desired between and Omni Antenna and a Yagi Antenna, then the Yagi Antenna must be installed in the vertically polarized position.
- Yagi Antennas installed in the vertically polarized position can only communicate with other Yagi Antennas that are also vertically polarized.
- When installing a dual antenna arrangement (repeating operation) both of the Yagi antennas can be installed horizontally polarized or vertically polarized. Additionally, one antenna can be installed horizontally polarized and the second antenna can be installed vertically polarized.

DISCONNECT SWITCH, DECAL AND WARNING SIGN

- If an antenna is mounted on a joint-use pole then mount a Disconnect Switch to the outside of the cabinet with a Decal next to the switch. Also mount the Warning Sign on the pole in the vicinity of the antenna.
- If an antenna is mounted on a DOT owned pole then the Disconnect Switch, Decal and Warning Sign can be omitted.

SECTION 1743
PEDESTALS

- Check for underground and overhead utility conflicts. Contact the engineer in charge of the plans if a readjustment is necessary.
- Verify pole height is correct for the particular application by consulting Roadway Standard Drawings 1705.02 and 1743.01 -1743.04.

SECTION 1745
SIGNS INSTALLED FOR SIGNALS

- If the plan does not show existing sign(s), it should be removed from the intersection.
- If it is determined that additional signs may be needed which are not shown on the plan, the Technician should coordinate with the Division Traffic Engineer and the engineer in charge of the plans to resolve the need.

SECTION 1750
SIGNAL CABINET FOUNDATIONS

- Locations may be adjusted for sight distances. Careful attention should be given to vehicles making a right turn on red. However, verify with the Division Traffic Engineer and engineer in charge of the plans.
- Ensure proper drainage is maintained around the cabinet foundations.

SECTION 1751
CONTROLLERS WITH CABINETS

- Because traffic signal controllers are very sensitive to electrical surges, care should be given to ensuring proper grounding is installed. Grounding specifications require an electrode resistance of 20 ohms at the connection point with the electrical service ground bus.
- Grounding electrode resistance should also be recorded on the "Inductive Detection Loops & Grounding Test Results" form (see Appendix A). The completed original form should be placed in the controller cabinet and a copy given to the Resident Engineer and Division Traffic Engineer. The form may be obtained electronically at the following web address:

https://connect.ncdot.gov/resources/safety/Pages/default.aspx

- Refer to Roadway Standard Drawings 1751.01 and 1751.02.
- Cabinets should be located so as not to obstruct sight distance of vehicles turning on red.
- Stencil the signal inventory number on the side of the cabinet that faces the roadway.
- The center of pole mounted cabinets should be approximately 4 feet above grade.
- On Type 170E Cabinets ensure the cabinet and cabinet extender are of the same finish. Also ensure the cabinet and conflict monitor are assembled for red monitoring.
- New controllers and cabinets must be tested in an enclosed workshop for eight hours minimum. Following this test and prior to installation, the equipment must be inspected by the Engineer. There is no direct payment for the workshop and testing.

SECTION 1752
MODIFY CABINET FOUNDATIONS

Existing cabinet foundations may be modified by either installing conduit entrances into the foundation or enlarging the existing foundation to accommodate a new cabinet and/or to provide a maintenance technician pad. Any damage to existing conduit, conductors, and anchor bolts must be repaired by the Contractor at no additional expense. A minimum work area of 24" (length) x 30" (width) from both the front and rear doors of the cabinet is required for maintenance technician pads.

SECTION 1753
CABINET BASE ADAPTER/EXTENDER

Cabinet base adapters and extenders are needed to allow sufficient room for personnel to work inside the traffic signal cabinet and store spare cable. Cabinet base extenders are usually 18 or 24 inches. The cabinet base extenders and adapters should be fabricated out of the same materials and with the same finish as the traffic signal cabinet.

SECTION 1755
BEACON CONTROLLER ASSEMBLIES

Beacon controller assemblies are also referred to as flashers. Cabinets should be located so as not to obstruct sight distance of vehicles turning on red. Stencil the signal inventory number on the side of the cabinet that faces the roadway. The center of pole mounted cabinets should be approximately 4 feet above grade.

SECTION 1757
REMOVAL OF EXISTING TRAFFIC SIGNALS

The Contractor should exercise care during removal so as not to damage other portions of the project or facility. Any damage must be repaired by the Contractor at no additional cost to the Department. Before deactivating the traffic signal, ensure that the required regulatory signs are installed. Signs should be covered until the traffic signal is removed or put into flashing operation. Consult the Division Traffic Engineer to determine if it is necessary to flash the traffic signal before removing the signal equipment.

The Contractor is required to transport the removed signal equipment to the Traffic Services Office. If any equipment is lost or damaged by the Contractor after removal, it must be replaced or repaired at no additional expense to the Department. The Contractor must label all returned equipment and material with its original location.

TRAFFIC SIGNAL SUPPORTS

General

This section is a project special provision. It is important that it be included in the Construction Manual because issues that occur with metal traffic signal supports can cause significant construction-scheduling delays and potential cost overruns. This section provides guidance to Resident Engineers and Technicians to help minimize the potential for problems during construction. Items discussed in this section are based on construction issues and resolutions that have been encountered on NCDOT projects.

Metal signal supports consist of either metal strain poles or metal poles with rigid mounted mast arms. They may be configured at signalized intersections using either metal strain poles, metal poles with mast arms, or a combination of both.

Metal pole standards have been developed and may be shown on signal plans. Some of these standards are on the Qualified Products List. Refer to Section 1700-2 and follow the Qualified Product List Instructions to determine if they apply to your project.

Construction Methods

- Overhead and underground utilities must be located and verified prior to beginning any work involving metal poles. If conflicts are encountered, the Contractor must gain approval prior to relocating any foundations and determine if the move will affect the structure design, or proper positioning of signals over the roadway. This is critical for metal poles with mast arms and could create costly and time consuming delays if not coordinated or handled in a timely manner. This should be documented in the construction diary in case mitigation is required.
- The Contractor is required to check that the pole heights required by the plans are of sufficient height to maintain proper signal head clearances for the finished cross-section including the final shoulder slopes. This is a critical milestone. It is highly recommended that the Technician verify the Contractor has performed this check and the Technician should be satisfied that the calculations provide for sufficient height.
- New roadway projects that have lengthy construction schedules can pose a construction dilemma for a signal Contractor. Metal signal supports typically are installed towards the end of the project. Yet, the signal Contractor must purchase metal signal supports early to ensure adequate shop drawing preparation and pole fabrication time and to receive them at the bid price quoted at the date of advertisement. However, if the roadway has not been constructed, there is no way for the signal Subcontractor to perform field verifications. He either has to assume that the project will be accurately constructed according to the cross-sections or wait until he can perform checks and verifications when final grades are established. The Technician should be aware of this and work closely with the Contractor in the event that final grade elevations vary as this could affect roadway clearances under the structure. Elevation adjustments for the foundations should be considered and allowed in these situations.
- When metal poles with mast arms are installed early on road widening projects, sometimes the signals have to be repositioned on the mast arm because of traffic shifts during construction. The Technician should instruct the Contractor to field drill wire access holes in

the arm only where the final signals will be Contractor positioned. These holes should be drilled on the underside of the mast arm to minimize water from entering and to allow moisture drainage from inside the arm. Additional signal wire should be provided outside of the arm to accommodate signal head shifts during temporary signal configurations.

- When installing leveling nuts on the foundation anchor bolts prior to setting the pole, consideration should be given to the effect that applied loads such as a mast arm or spanwire tensioning will have on the verticality of the pole. The Contractor may need to adjust the leveling nuts before and after the structure is fully erected and loaded to ensure the vertical tolerances specified are met. Extreme caution should be exercised when making any adjustments to the nuts that secure the structure to the foundation when the structure is in a fully loaded condition.
- When metal signal supports are erected on foundations, ensure the Contractor follows the Anchor Nut Tightening Specifications, which can be found in Appendix E. When the vertical support is erected, the top and leveling nuts should be fully tightened before installing the arm and /or applying additional loads to the structure. Once the structure has been fully assembled and is in a fully loaded condition, all of the nuts should be rechecked to ensure they are fully tightened. It is important to re-check and verify that all base plate connections are tightened according to the nut tightening procedure no less than 48 hours after the structure is fully erected and loaded. Leveling nuts, particularly ones located on the back side of a newly installed pole or opposite a mast arm or a span wire induced load, often become loose because of the base plate trying to pull away from the leveling nuts. Signal supports should not be accepted until this final check has been performed to the satisfaction of the Technician.
- The project should not be delayed due to the unavailability of metal signal supports. If metal poles are unavailable when needed, the Contractor should contact the engineer in charge of the project to seek a resolution. This may require installing wood poles on a temporary basis. If metal pole unavailability is not due to the fault of the Contractor, additional compensation for the wood pole installation may be warranted. However, if the unavailability is due to the fault of the Contractor (such as a failure to coordinate his work activities in a timely manner), no compensation should be warranted.

METAL STRAIN POLES

Metal strain poles are metal poles with messenger cable (spanwire) attached to the poles to suspend traffic signals over the roadway. Strain poles provide a good alternative to wood poles in areas with very limited right-of-way. They are structurally designed for specific loadings and locations. They can be moved around within the general area required by the plans to avoid unanticipated obstacles without compromising their structural stability. However, if they are moved make sure the traffic signal heads still meet visibility and roadway clearance requirements. If a pole needs to be moved a substantial distance, or if the move creates a very acute internal angle between the signal span wires, a structural analysis may be necessary.

METAL POLES WITH MAST ARMS

Metal poles with mast arms are metal poles with rigid mast arms attached to the poles that support traffic signals and signs over the roadway. Like strain poles, they provide good alternatives to wood poles in areas where right of way is limited. They are best suited for use in areas where high winds are common or in areas where aesthetic appeal is important such as an historic district, urban areas, or in areas where all utilities are underground. Because this type of

support is designed site specifically where arm lengths are determined by optimal signal positioning over the roadway, they are not conducive to being relocated from their original design location.

DRILLED PIER FOUNDATIONS

Drilled pier foundations are steel reinforced concrete piers constructed and cast against undisturbed soil. They vary in size and depth based on the traffic signal structure they are designed to support. Installation methods may vary depending on soil conditions and construction constraints. It is important that the Contractor communicate to the Resident Engineer his proposed method for these installations.

- Soil tests are required for each proposed foundation. The Contractor must submit this information to the engineer responsible for the foundation design. Failure to do so can create delays in the approval of the foundation designs.
- The Resident Engineer should make every effort to avoid having unsuitable material such as rock and old pavement placed in fill areas where these foundations will be placed. Failure to comply with this could create abnormal soil test results and installation problems for the foundations.
- It is important that locations where these foundations will be installed (such as built up shoulders and slope embankments) be constructed with proper compaction to help ensure that these drill shafts will not collapse during initial augering.
- Geotechnical field engineers are available to provide assistance in resolving foundation construction problems. Their input can be crucial to help resolve unanticipated construction issues when unstable or unsuitable material is encountered during construction.

For Divisions 1-7 contact:
The Eastern Regional Operations Engineer

Eastern Regional Office (Divisions 1-7)	PHONE: (919) 662-4710
1570 Mail Service Center (MAIL)	FAX: (919) 662-3095
Raleigh, NC 27699-1570	
3301 Jones Sausage Rd., Suite 100 (DELIVERY)	
Garner, NC 27529-9489	

For Divisions 8-14 contact:
The Western Regional Operations Engineer

Western Regional Office (Divisions 8-14)	PHONE: (704) 455-8902
5253 Z Max Boulevard	FAX: (704) 455-8912
Harrisburg, NC 28075	COURIER: 05-37-01

STRUCTURE DESIGN OF SIGNAL SUPPORTS

This provision is used when the Department's standard designs are not applicable. This may be due to loading criteria of the signal supports, special decorative or aesthetic requirements, or other unique site specific requirements. The Technician should carefully consult the project plans and Project Special Provision for any unique requirements.

- Under this section, the Contractor is to provide pole and foundation designs for metal strain poles and metal poles with mast arms as specified by the project plans.

- Fabrication time can be relatively long, ranging from 2 months to 6 months or more. Therefore, it is essential that the Technician encourage the Contractor to submit all required shop drawings as early in the project as possible and that this is recorded in the construction diary.
- Overhead and underground utilities should be located and verified prior to beginning any work involving metal poles including the design of the structures.
- The Contractor is required to check that the pole heights required by the plans are of sufficient height to maintain proper signal head clearances for the finished cross-section including the final shoulder slopes prior to submitting shop drawings. This is a critical milestone. It is highly recommended that the Technician verify that the Contractor has performed this check and the Technician also should be satisfied that the calculations provide for sufficient height.
- Shop drawings submitted for approval should be sent to the State ITS and Signal Systems Engineer. Unless otherwise specified, please allow up to 40 calendar days for review (Section 105-2).

OTHER SIGNAL RELATED REQUIREMENTS

CROSSWALKS AND WHEELCHAIR RAMPS

Maintain the minimum 4-foot clearance between the stopbar and crosswalk. Contact the Engineer in charge of plans if the minimum clearance can not be maintained.

STOPBARS

Stopbars are placed according to the location specified on the transportation management plan for temporary patterns and on the pavement marking plans for final patterns. The Technician should compare the transportation management plans and pavement marking plans with the signal plans and if a discrepancy is noted, the engineer in charge of the plans should be contacted immediately for a resolution. Stopbars should be located when the curb cuts are being laid out to ensure the curb cuts will be placed in the correct location.

MODIFICATIONS

- If a temporary signal is needed during construction for a detour contact the State Signals Engineer.
- If there are coordination issues between 2 adjacent projects contact the Engineer in charge of the plans.
- If there is a modification request contact the Engineer in charge of the plans.

CLOSED LOOP SYSTEM INSPECTION

- Ensure that communications with the intersection controllers and other intersection equipment to the personal computer is through the on-street masters with standard 2-way system communications.
- Ensure that each intersection actuation (local) detector can be monitored for constant calls and absence of calls.
- Ensure that each system detector can be monitored for constant calls, absence of calls, and erratic output. Ensure that all such anomalies are reported by the on-street master to the personal computer.
- Ensure that the on-street masters collect monitoring and detector information from the associated intersections, temporarily store the information, and report the information to the microcomputers.
- Ensure that on-street master communications equipment performs parity and error checking diagnostics to assure communication of valid system data.
- The Division Traffic Engineer should be contacted to verify proper closed loop system operation prior to acceptance of the project.
- Do not accept the project until proper operation of the communications equipment and closed loop system has been verified.

UTILITY MAKE-READY PLANS

WHAT ARE "UTILITY MAKE-READY" PLANS?

Utility Make-Ready Plans are developed to establish a clear right-of-way for the installation of proposed NCDOT communications cables on TIP and non-TIP projects. Mainly this work is associated with the future installation of a communications cable that will be installed underground in a conduit system or overhead/aerial on utility poles.

ARE THESE PLANS INCLUDED IN THE BID DOCUMENT AND CONSTRUCTION PLANS?

No. They are not included as part of the Bid Document and Construction Plans. The work associated with the Utility Make-Ready plans is **not** part of work to be performed by the Contractor. Work to be performed as part of the Utility Make-Ready plans is actually work that is to be undertaken by the Utility Companies, and should be handled during the time that the overhead utilities are being re-worked or in some cases re-located.

However, you will find Communications Cable and Conduit Routing Plans in the Construction Plans, which address work that is to be performed by the Contractor.

WHY DOES NCDOT USE COMMUNICATIONS CABLE?

NCDOT uses communications cable to establish communications media between many different types of electronic devices such as traffic signal controllers, closed circuit television cameras (CCTV Cameras), dynamic message signs (DMS), weather stations, reversible lane systems, metropolitan signal systems, and for communications between Traffic Operation Centers (or Traffic Mgmt. Centers).

WHAT IS INVOLVED WITH DEVELOPING UTILITY MAKE-READY PLANS?

First, the outer limits of the project are established. In most cases this means establishing the location of all the electronic devices to be interconnected via a specified communications medium. Once the limits are established, a field survey is conducted to record basic field information such as road names, street names, and other vital information. Also, as part of the field survey, information pertaining to the existing overhead utilities is recorded. This includes all existing joint use utility poles and signal poles. Distances between the various poles are recorded along with relative locations of the poles with regards to streets and other landmarks. In addition to recording the pole location, the heights of the existing utilities on each pole are reviewed in the field and recorded. As part of this process, determinations are made as to what utility adjustments (if any) are needed to establish an attachment point. Attachment points on overhead joint use poles are governed by the **National Electrical Safety Code (NESC).** In some cases this may even mean replacing poles or justifying installing our cable in an underground conduit system.

Once the field survey is completed, the information is placed on a set of Preliminary Utility Make-Ready Plans using the CADD. Next a meeting is established with representatives from the DOT (Transportation Mobility and Safety Division, Division Traffic Engineer/Traffic Services, etc.) and the affected Utility Companies to review the proposed preliminary make-ready work. During this meeting the plans are discussed and any work asked to be performed by

the Utility Company is discussed and agreed upon. If alternative solutions are made available the plans are changed to reflect them and a final set of Utility Make-Ready Plans are prepared.

Upon completing the Finalized Utility Make Ready Plans a copy is forwarded to the State Utility Agent, Division Traffic Engineer, Resident Engineer and the Utility Companies.

WHAT ARE THE REQUIREMENTS OF THE NATIONAL ELECTRICAL SAFETY CODE YOU REFER TO ABOVE?

The National Electrical Safety Code (NESC) is a nationally accepted standard which addresses basic provisions for safeguarding persons from hazards arising from the installation, operation, or maintenance of 1) conductors and equipment in electrical supply station, and 2) overhead and underground electrical supply and communication lines. Communications cable falls under item #2 listed above.

As with many nationally accepted standards, the authority having jurisdiction can make certain exceptions to these rules. This is a very comprehensive document. Therefore, in lieu of trying to explain this document or ask the Resident Engineer to become familiar with this document, we have taken the liberty to include several drawings and tables that address the main guidelines that we meet and/or exceed.

Please reference the "MINIMUM UTILITY CLEARANCE REQUIREMENTS" (see Appendix B) for general attachment guidelines and additional information.

AS A RESIDENT ENGINEER WHAT DO I DO WITH A SET OF UTILITY MAKE-READY PLANS?

As stated above, the plans indicate work actions that are to be taken by the existing utilities. During the time that the utilities are working to relocate the existing facilities to accommodate the anticipated roadway work, the Utility Companies should also be addressing any work items that are shown on the Departments Utility Make-Ready plans.

The Resident Engineer is advised to become familiar with these plans to help ensure that the utilities are reattaching or making adjustments to the joint use poles to accommodate the future installation of our communications cable. The Resident Engineer must survey the work being performed by the Utility Company to help identify potential problems. Upon completion of Utility Make-Ready work, the Resident Engineer needs to continue to inspect the pole line to ensure that the space allocated for the NCDOT's cable is maintained. This will go a long way to help eliminate any future problems that may exist when it becomes time for the NCDOT Contractor to install the cable.

WHAT ARE "COMMUNICATIONS CABLE AND CONDUIT ROUTING PLANS"?

The Communications Cable and Conduit Routing Plans are included as part of the Construction Plans. The work associated with the Communications Cable and Conduit Routing Plans are that portion of the project that the NCDOT Contractor is responsible for performing. The Communications Cable and Conduit Routing Plans may be a stand-alone set of plans in the overall bid package or in other cases be included as part of the Signal Plan Package.

The Communications Cable and Conduit Routing Plans give detailed instruction to the Contractor concerning the installation of the communications cable. These plans take into account the information that was discussed in the Utility Make-Ready Plans and provide additional information regarding where along the project limits to install the communications

cable overhead/aerially or underground. They also identify the height and/or location that the communications cable is to be attached.

WHO DO I CALL WITH QUESTIONS?

For questions or concerns dealing with Utility Make-Ready Plans or Communications Cable and Conduit Routing Plans you should contact the ITS & Signals Engineer of the Transportation Mobility and Safety Division.

DEFINITIONS

Actuation – A registration of demand for right-of-way by traffic to the controller unit.

Antenna - a conductor by which electromagnetic waves are sent out or received over the airways.

Attenuation – The decrease in magnitude of signal power in transmission between points. A term used for expressing the total loss of an optical system, normally measured in decibels (dB) at a specific wavelength.

Backplate – A black metal plate attached to a signal head used to increase the target value of the signal face (used when signal face is not readily visible to motorist due to competing background lighting such as commercial signs and lights, sunlight, etc).

Bandwidth – The range of signal frequencies that a modem or channel will respond to, or carry without excessive attenuation.

Baud – A unit for expressing the rate at which information is transmitted. A rate of one baud is one useful signal element per second.

Bonded - A permanent joining of metallic parts to form an electrically conductive path.

Buffer Tubes – Extruded cylindrical tubes used for protection and isolation encasing optical fibers.

Cabinet – An enclosure for housing the controller and associated equipment.

Cable Bending Radius – The smallest radius bend for a cable that can be made without damaging the cable (as recommended by the manufacturer).

Call – see Actuation

Call Delay – For a detector unit, the ability to delay its output to the controller for a predetermined length of time after a vehicle enters the detection zone. For a controller, the ability to disregard a call from a detector unit for a predetermined length of time.

Cladding – The material surrounding the core of an optical fiber. The cladding keeps the light in the fiber core.

Closed Loop System (CLS) – A signal system in which signals are connected to a master controller. The master controller selects timing patterns for the system, which may be traffic-responsive or time-of-day. The master is connected to a computer in a central office. The computer can be used to monitor the system, make timing changes and receive reports of signal malfunctions.

Coaxial Cable - a cable consisting of an inner insulated core of stranded or solid wire surrounded by an outer insulated flexible wire braid, used esp. as a transmission line for radio-frequency signals.

Condulet – A fitting for attaching two or more pipes (risers) at a junction to allow protection and access of electrical wires and cables.

Conflict Monitor – A device located inside the cabinet (usually separate from controller) that continually checks for the presence of conflicting signal indications. Upon detection of conflicting indications, the conflict monitor will cause the signal to go into flash.

Controller (Signal Controller) – A device which controls the sequence and duration of indications displayed by traffic signals. See also NEMA Controller and Type 170 Controller.

Coordination – A timing relationship between adjacent signals that allows traffic to progress smoothly along a corridor.

Decibel (dB) – Unit for measuring the relative strength of light signals expressed in dB's.

Demultiplexing – The process of retrieving two or more communication channels from a multiplexed transmission media.

Detection Zone – The area of the roadway where a vehicle will cause actuation.

Dielectric – Non-Metallic and, therefore, non-Conductive. Glass fibers are dielectric. A dielectric cable contains no metallic components.

Emergency Vehicle Preemption – A type of preemption in which the normal signal sequence is interrupted, giving right of way to emergency vehicles (see also Preemption).

Fiber – A thin filament of glass. An optical waveguide consisting of a core and a cladding that is capable of carrying information in the form of light.

> ***Multimode Fiber (****MMFO)* – A type of optical fiber that supports more than one propagating mode (used primarily for Local Area Networks or other applications that do not cover long distances (i.e., 2 miles or less) – not used on current project designs). The fiber has a core diameter of approximately 62.5 microns.
>
> ***Single-Mode Fiber*** *(SMFO)* – A type of optical fiber in which the signal travels in one mode. The fiber has a small core diameter of approximately 9 microns. Used primarily for communications in transportation applications that may cover longer distances than via MMFO cable.

Fiber Optic Jumper – Optical fiber cable that has connectors installed on both ends.

> *Note:* The industry Standard utilizes a Yellow jacket for SMFO jumper and an Orange jacket for MMFO jumper.

Fiber Optic Pigtail – Optical fiber cable that has a connector installed on one end.

> *Note:* The industry Standard utilizes a Yellow jacket for SMFO pigtail and an Orange jacket for MMFO pigtail.

Fiber Optic Receiver – An electronic device that coverts optical signal to electrical signals.

Fiber Optic Splice – An interconnection method for joining the end of one bare fiber to another fiber.

> ***Fusion Splice*** – A permanent joint produced by the application of localized heat sufficient to fuse the ends of the optical fiber, forming a continuous light signal path.
> ***Mechanical Splice*** – A method of joining two fibers together by permanent or temporary mechanical means to enable a continuous light signal path.

Fiber Optic Splice Enclosure – A container used to house a cable run splice point, and organize and protect splice trays.

Fiber Optic Splice Tray – A container used to secure, organize, and protect spliced fibers.

Fiber Optic Transceiver – An electronic device that converts optical signals to electrical signals and converts an electrical information-carrying signal to a corresponding optical signal for transmission by fiber. A transceiver is one device consisting of a transmitter and a receiver.

Fiber Optic Transmitter – An electronic device used to convert an electrical information-carrying signal to a corresponding optical signal for transmission by fiber. The transmitter is usually a Light Emitting Diode (LED).

Fiber Optics – Light transmission through optical fibers for communication or signaling.

Free-Run Operation – A mode of operation for a traffic signal in which assignment of right of way indications is governed by demand at the intersection in question, rather than determined by system-wide demand.

Grounded – An electrical connection to the earth to prevent the buildup of unwanted voltage that may result in undue hazards to connected equipment and personnel.

Inductive Loop – A loop of electrical wire placed in the roadway for vehicle detection.

Interconnect Cable – The cable that provides the means to transmit information in a signal system.

Junction Box (Pull Box) – A container usually placed underground with a removable top flush with ground level that serves as a location for splicing loop wire to lead-in wire or to allow for the pulling of cable through conduits.

Lightning Arrestor - a device used on electronic systems (Wireless Radios) to insulate the system from the damaging effect of lightning. The typical lightning arrester, also known as surge arrester, has a high voltage terminal and a ground terminal. When a lightning surge or switching surge travels down the power system to the arrester, the current from the surge is diverted away from the electronic equipment. In most cases the surge is directed to an earth ground path.

Link – A telecommunications circuit between any two telecommunication devices.

Load Switch – An electrical device activated by the controller that turns power on or off for the traffic signal indications.

Loop – see Inductive Loop

Loose Tube Cable – Type of cable design whereby colored fibers are encased in buffer tubes.

Master Controller – A controller which supervises interconnected secondary controllers.

Messenger Cable – see Span Wire

Multiplexing – The combining of several signals into one channel.

Multiplexor (MUX) – A device which uses several communication channels at the same time, transmits and receives messages and controls the communications lines. This device may or may not be a stored program computer.

Optical Time Domain Reflectometer (OTDR) – An instrument that measures transmission characteristics by sending a series of short pulses of light down a fiber and providing a graphic representation of the backscattered light.

Optically Programmed Head – A signal head containing optical units projecting an indication which is selectively masked so as to be visible only within desired viewing boundaries.

Patch panel – A collection of connector panels in a common housing.

Point-to-point – A connection established between two specific locations (such as between two traffic signal controller cabinets).

Preemption- Transfer of the normal control of a signal to a special signal control due to a special situation such as passage of a train or granting of right of way to an emergency vehicle.

Pull Box – see Junction Box.

Quadrupole Loop – An inductive loop design with a longitudinal saw slot along the center of a rectangular loop so that the loop wire can be installed in a figure-eight pattern. These loops are especially useful in the detection of small vehicles.

Radio Frequency - the frequency at which electromagnetic waves are transmitted.

Railroad Preemption – A type of preemption in which the normal signal sequence is interrupted when a train is approaching. Railroad tracks are cleared of vehicles and right of way is granted to vehicle movements that do not conflict with the train movement.

Spanwire - Messenger Cable) – A cable used to support traffic signals heads, electrical cable and/or signs.

Standard Signal Face Clearances – A standard chart that shows how each signal clears from each phase.

Table of Operation – A table that indicates the display for each signal head during each right of way interval.

Trunk – A transmission link joining two points which is distinguished by its large information carrying capacity and by the fact that all signals go from point to point without branching off to any separate drops except at the end points.

Visor (Hood) – That part of the signal head section which shields the lens face from direct light (sunlight).

Wireless Radio - any device that transmits or receives messages or signals by electromagnetic waves.

TECHNICIAN'S CHECKLIST
SECTION 1700
SIGNALS AND INTELLIGENT TRANSPORTATION SYSTEMS

1) Study the Specifications, plans, and Project Special Provisions.
2) Verify that materials supplied are the same as those shown on the approved catalog cuts, shop drawings and Qualified Products List (QPL).
3) Ensure the Contractor has reported any defective equipment prior to beginning any signal work.
4) Ensure junction boxes are set flush to grade and the cover is bolted to the base.
5) Ensure marking and code letters are burn-branded on the wood pole or printed and attached metal tag.
6) Ensure all equipment is installed in accordance to the approved plans.
7) When installing any overhead cables on joint use utility poles, or any other electrical equipment ensure it is installed in accordance with the requirements of the National Electrical Safety Code (NESC) and any other codes or ordinances adopted by the various utility companies.
8) For any questions that arise during construction contact the engineer in charge of the plans in the Transportation Mobility and Safety Division.

APPENDIX

I. **Appendix A – Inductive Detection Loops and Grounding Test Results**
II. **Appendix B – Minimum Utility Clearance Requirements**
III. **Appendix C - Interconnect Centers and Splice Enclosures**
IV. **Appendix D - Steve Varnedoe Memorandum (12-5-05) - "Intersection Inspections Checklist"**
V. **Appendix E - Anchor Nut Tightening Specification**

APPENDIX A –INDUCTIVE DETECTION LOOPS ANS GROUNDING TEST RESULTS

Inductive Detection Loop & Grounding Test Results

Location: _____ Sig. Inv. #: _____

Inspected By: _____ /Contractor's Name Date Tested: _____

Loop No.	Sealant Type	Distance from Stop Bar	Megger Reading @ Pull Box (> 100 megohms)		Megger Reading @ Signal Cabinet (> 50 megohms)		Ohm Reading @ Signal Cabinet Length of Loop Wire & Lead-in Wire _____feet/meter (<0.0036 ohms/foot) #14 AWG (< 0.012 ohms/meter) #14 AWG		
			Reading	Date	Reading	Date	Reading	Feet / Meter	Date

Grounding

Number of Ground rods? _____
(3 Rod Minimum)

How are the ground rods installed? ☐ Individually ☐ Stacked

Ohm Reading? _____

Amount of ground wire? _____
(From cabinet to closest ground rod)

Ground Rod Location

(Draw in cabinet & locate ground rods)

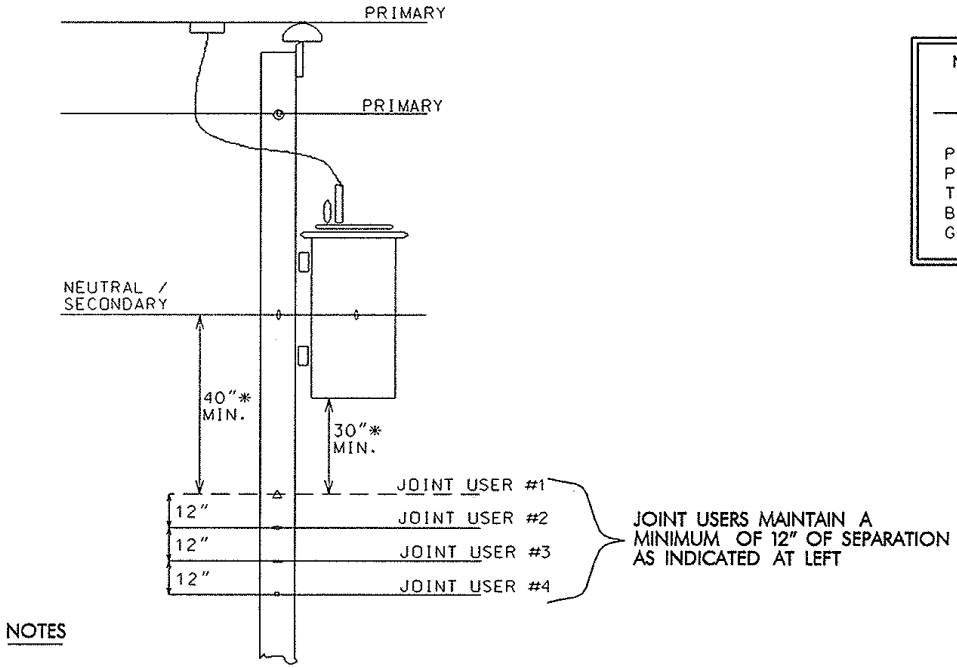
SIDE STREET

NOTES:

- **When using clamp-type ground resistance meters, readings of less than 1 ohm typically indicate a ground loop. Rework bonding and grounding circuits as necessary to remove ground loop circuits and retest.**
- **Grounding of traffic signal controller cabinets should be in accordance with Section 1700 of the NCDOT Standard Specifications for Roads and Structures and drawing numbers 1700.01 and 1700.02 of the Roadway Standard Drawings.**
- **The installation and testing of inductive detection loop systems should be in accordance with Sections 1725 and 1726 of the NCDOT Standard Specifications for Roads and Structures and drawing number 1725.01 of the Roadway Standard Drawings.**

APPENDIX B

MINIMUM UTILITY CLEARANCE REQUIREMENTS



NCDOT MINIMUM ATTACHMENT CLEARANCES FROM OTHER JOINT USERS AT THE POLE

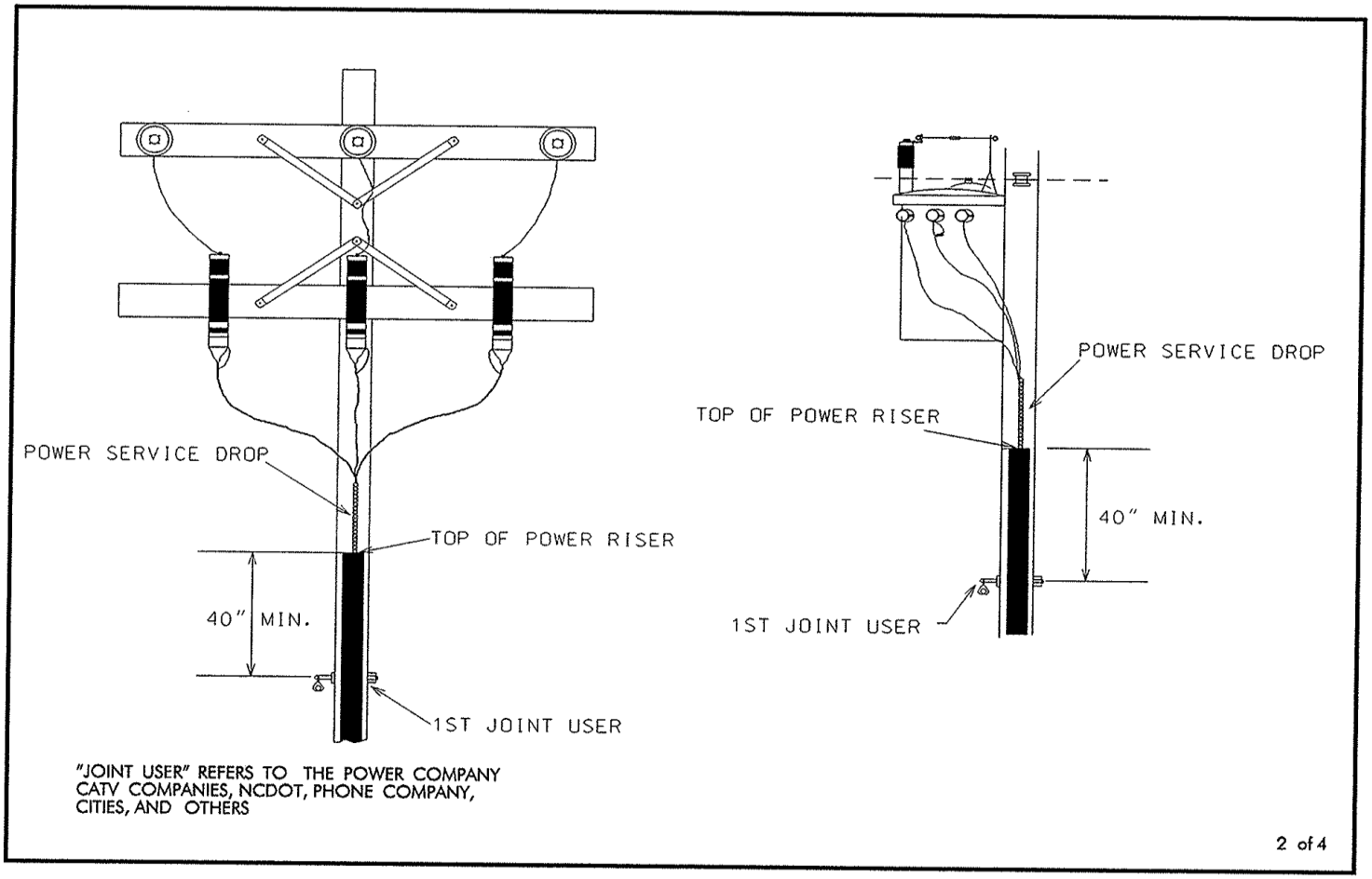
CLEARANCE FROM	MIN. DISTANCE
POWER SERVICE DROP	40"
POWER SERVICE DRIP LOOP	40"
TOP OF POWER RISER	40"
BOTTOM OF TRANSFORMER	30"
GUY ATTACHMENT	12"

NOTES

THE ATTACHMENT POINT FOR JOINT USER #1 MUST MAINTAIN A MINIMUM OF 40" BELOW POWER AND/OR A MINIMUM OF 30" BELOW BOTTOM OF TRANSFORMER (WHICHEVER IS GREATER)

"JOINT USER" REFERS TO THE POWER COMPANY CATV COMPANIES, NCDOT, PHONE COMPANY, CITIES, AND OTHERS

1 of 4


POWER SERVICE DROP
TOP OF POWER RISER
40" MIN.
1ST JOINT USER
"JOINT USER" REFERS TO THE POWER COMPANY
CATV COMPANIES, NCDOT, PHONE COMPANY,
CITIES, AND OTHERS
POWER SERVICE DROP
TOP OF POWER RISER
40" MIN.
1ST JOINT USER
2 of 4

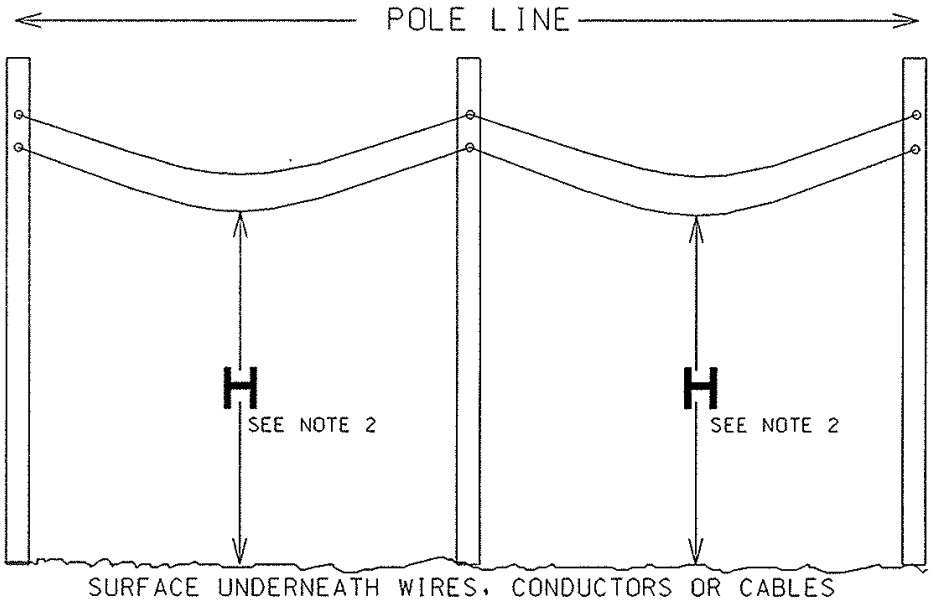


TABLE 1

NATURE OF SURFACE UNDERNEATH WIRES, CONDUCTORS OR CABLES	MINIMUM CLEARANCE (H)*
1. TRACK RAILS OF RAILROADS EXCEPT ELECTRIFIED RAILROADS USING OVERHEAD TROLLEY CONDUCTORS	30 FT
2. ROADS, STREETS AND OTHER AREAS SUBJECT TO TRUCK TRAFFIC	18 FT
3. DRIVEWAYS, PARKING LOTS, AND ALLEYS	18 FT
4. OTHER LAND TRAVERSED BY VEHICLES SUCH AS CULTIVATED, GRAZING, FOREST ORCHARDS, ETC.	18 FT
5. SPACES AND TRAVEL WAYS SUBJECT TO PEDESTRIAN OR RESTRICTED TRAFFIC ONLY	15.5 FT

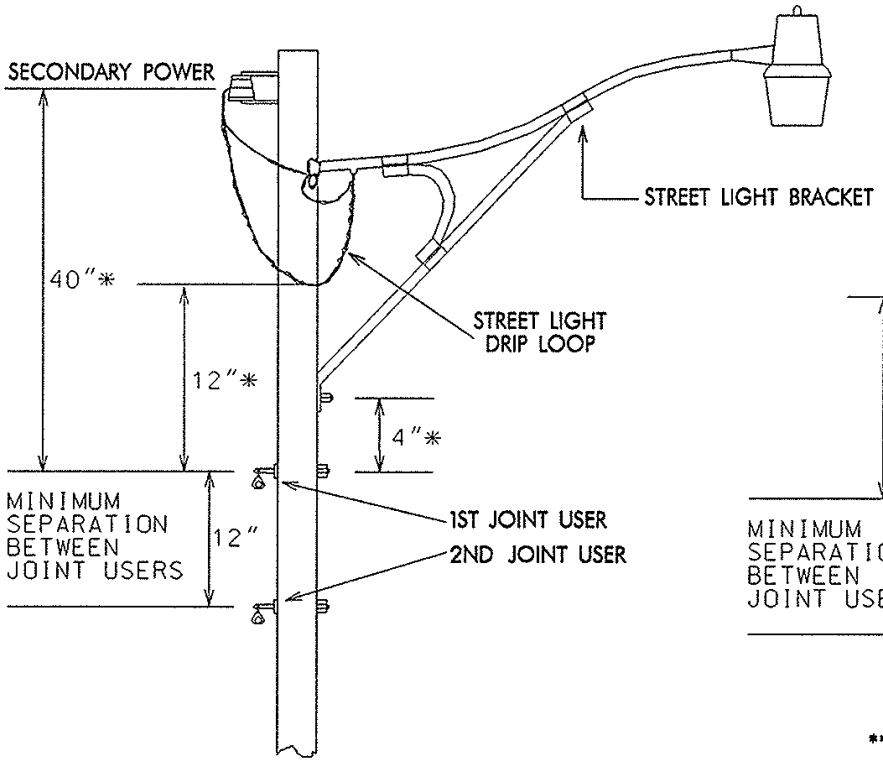
* THESE VALUES HAVE BEEN ADOPTED BY NCDOT (AS WELL AS VARIOUS UTILITY COMPANIES) AND EXCEED THE SPECIFICATIONS AS SET FORTH IN THE NATIONAL ELECTRICAL SAFETY CODE (NESC).

NOTES:

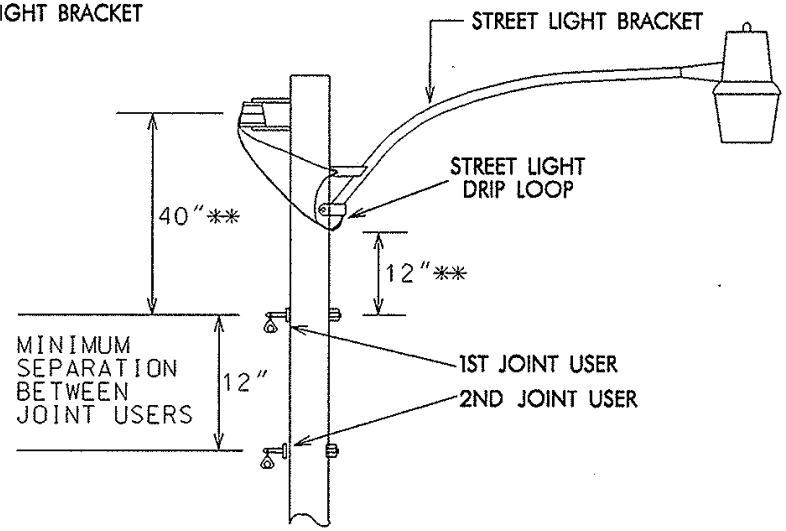
1. SEE TABLE 1 FOR ACCEPTABLE MINIMUM CLEARANCE VALUES (H) OVER VARYING SURFACES
2. "H" IS DEFINED AS THE VERTICAL DISTANCE (HEIGHT) AS MEASURED FROM THE LOWEST POINT (TYPICALLY MIDSPAN) OF THE WIRES, CONDUCTORS OR CABLES TO THE SURFACE BELOW
3. SAG BETWEEN POLES SHOULD BE MATCHED TO THAT OF THE SURROUNDING UTILITIES

3 of 4

STREET LIGHT CLEARANCES



* ALL THREE OF THESE
MINIMUM CLEARANCE REQUIREMENTS
AT STREET LIGHTS MUST BE MET



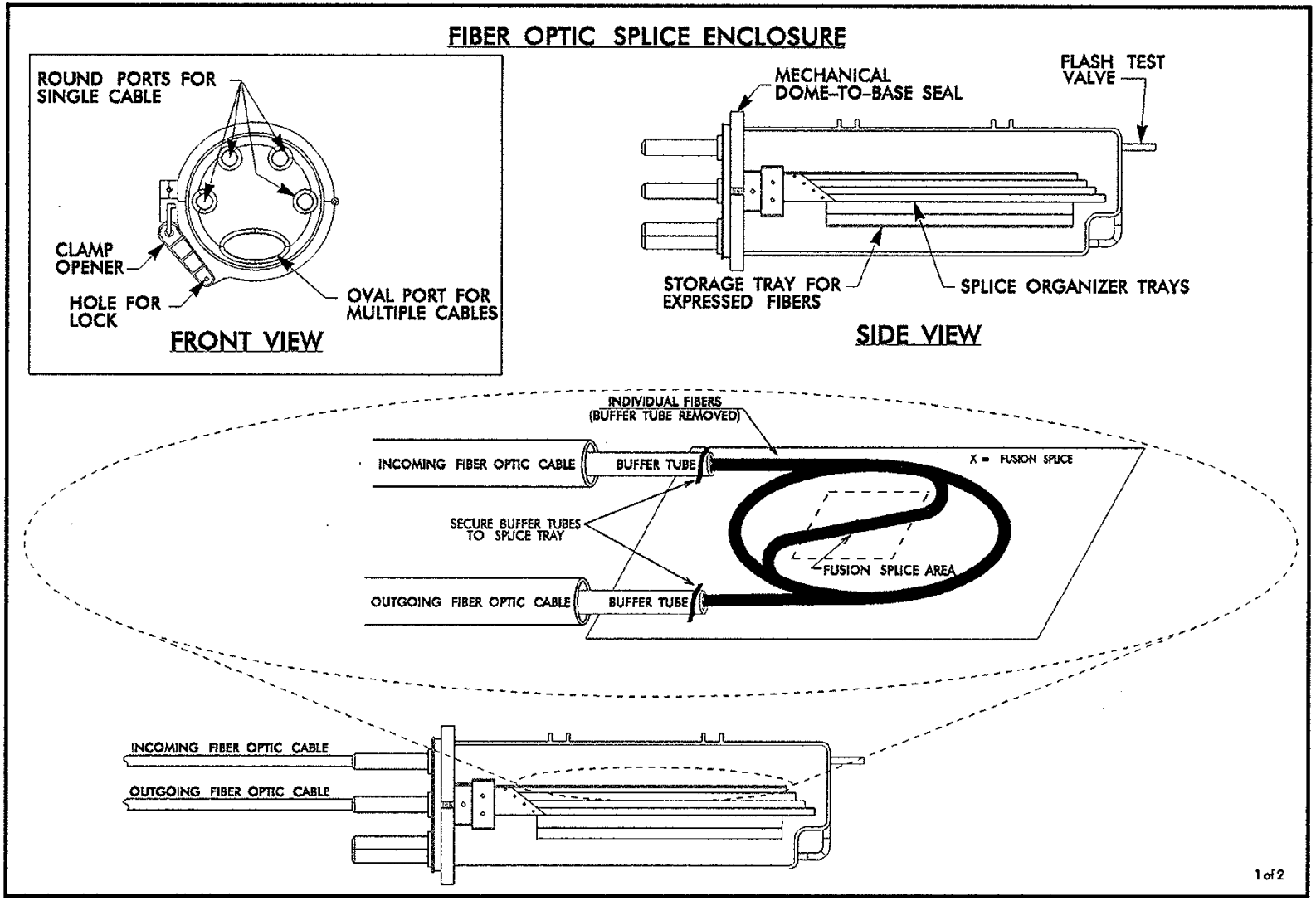
**BOTH OF THESE
MINIMUM CLEARANCE REQUIREMENTS
AT STREET LIGHTS MUST BE MET

"JOINT USER" REFERS TO THE POWER COMPANY
CATV COMPANIES, NCDOT, PHONE COMPANY,
CITIES, AND OTHERS

4 of 4

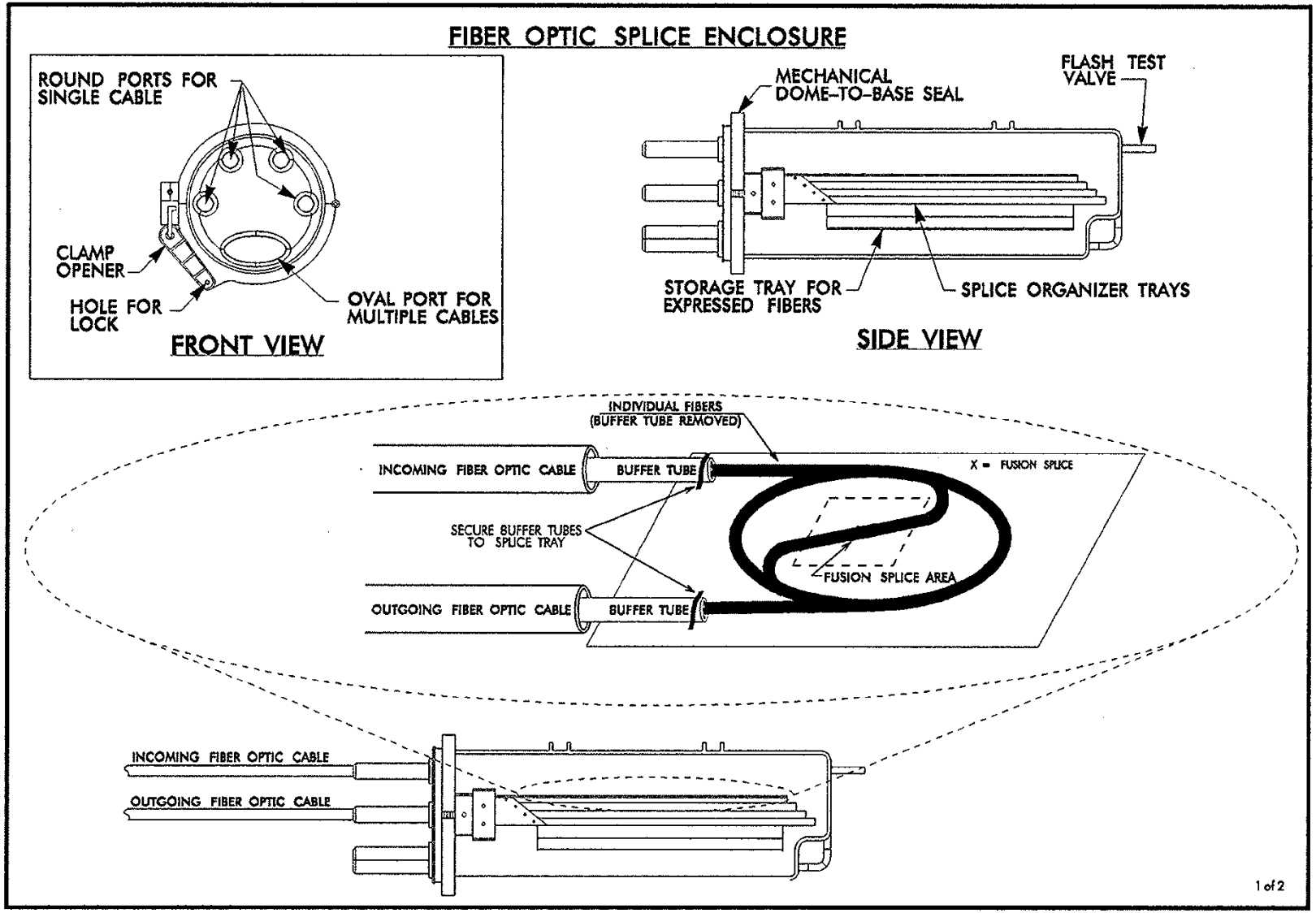
APPENDIX C

INTERCONNECT CENTERS AND SPLICE ENCLOSURES



APPENDIX C

INTERCONNECT CENTERS AND SPLICE ENCLOSURES



APPENDIX D – INTERSECTION INPSECTION CHECKLIST

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

LYNDO TIPPETT
SECRETARY

December 5, 2005

MEMORANDUM TO: Division Engineers

FROM: W. S. Varnedoe, P.E.
Chief Engineer – Operations

SUBJECT: Intersection Inspection Checklists

A few months ago, I advised you of several process improvements that were generated from the 2005 Contractor/DOT Conference. One of the proposals focused on improving Contractor/DOT communication to facilitate project closeout with a recommendation to develop a list of common punch list items historically encountered on projects. In an effort to continue the communication of DOT expectations and educate project personnel about critical inspection needs, the ITS and Signals Unit has developed an Intersection Inspection Checklist. This checklist should be presented to the Contractor and Signal Subcontractor at the Preconstruction Meeting. The Contractor should incorporate the Intersection Inspection Checklist into their quality control program and be expected to correct deficiencies prior to final inspection.

It remains critical that we communicate expectations and concerns with the contractor throughout the life of our projects. Please review this information with your staff and ask them to begin using this new checklist on all projects immediately.

WSV:saj

Attachment

cc: Len A. Sanderson, P.E., State Highway Administrator
W. F. Rosser, P.E., Director of Field Operations
Lacy Love, P.E., Director of Asset Management
S. D. DeWitt, P.E., Director of Construction
Deborah Barbour, P.E., Director of Preconstruction
E. C. Powell, Jr., P.E., State Construction Engineer
Cecil Jones, P.E., State Materials Engineer
Kevin Lacy, P.E., CPM, State Traffic Engineer
Resident Engineers
District Engineers
Division Traffic Engineers
Roadway Construction Engineers
Berry Jenkins, P.E.

MAILING ADDRESS:
NC DEPARTMENT OF TRANSPORTATION
CHIEF ENGINEER'S OFFICE
1537 MAIL SERVICE CENTER
RALEIGH NC 27699-1537

TELEPHONE: 919-733-7621
FAX: 919-733-4141

WEBSITE: WWW.DOT.STATE.NC.US

LOCATION:
TRANSPORTATION BUILDING
1 SOUTH WILMINGTON STREET
RALEIGH NC

INTERSECTION INSPECTION CHECK-LIST
NC PROJECT: _____

INTERSECTION LOCATION _____

SIGNAL INVENTORY NO. _____

PART I (to be completed by Resident Engineer's Office)

Inspected By: _____ Date Inspected: _____

I. Cabinet			
a. Exterior appearance, level/plumb?	APPROVED ☐		REJECTED ☐
b. Cabinet bottom, base adapter, & extension sealed & weather-tight?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
c. Attached securely to foundation?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
d. Foundation has required spare conduit stubouts?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
e. Foundation pad properly sized?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
f. Both doors fully open with no obstructions?	APPROVED ☐		REJECTED ☐
g. Attached securely to pole?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
h. Inventory Number on Cabinet?	APPROVED ☐		REJECTED ☐
J. Markings - Centerline / Edgeline Correct size and located properly?	APPROVED ☐		REJECTED ☐
Markings - Lane-use Correct size and located properly?	APPROVED ☐		REJECTED ☐
Markings - Stop Bars Correct size and located properly?	APPROVED ☐		REJECTED ☐
Markings - Crosswalk and Wheel Chair Ramps Correct size and located properly?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
Vehicular and Pedestrian Signal Heads a. Correct signal face configuration?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
b. Proper height?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
c. Aligned properly with approach?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐

d. Gooseneck and balance adjuster tightened?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
e. Utility lines, etc. do not block view?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
Signs - Static and Blank-out Correct message, size, location?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
Inductive Detection Loops a. Installed properly?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
b. Tail section wires twisted?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
c. Located per plans?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
d. Loop numbers and polarity marked on cable ties in junction boxes?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
e. Resistance and megger readings forwarded to Division Traffic Engineer?	YES ☐	NOT APPLICABLE ☐	NO ☐
Junction Boxes - Traffic Signal and Fiber Optic a. Properly sized per plans?	APPROVED ☐		REJECTED ☐
b. Top flush with finish grade?	APPROVED ☐		REJECTED ☐
c. Stone base added before placing junction box?	APPROVED ☐		REJECTED ☐
d. Conduits sealed?	APPROVED ☐		REJECTED ☐
e. Proper message on cover?	APPROVED ☐		REJECTED ☐
f. Cover secured and in good condition?	APPROVED ☐		REJECTED ☐
Electrical Service a. Grounding electrode wire exothermically welded to ground rods?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
b. Ground rod resistance recorded and forwarded to Division Traffic Engineer? NOTE: A resistance reading of 0.7 ohms indicates an error in the measurement.*	YES ☐	NOT APPLICABLE ☐	NO ☐
Pole-Line Hardware a. Proper type (angle, sidewalk, horizontal) of guy used?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
b. Proper separation between holes in wood pole?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
c. No strandlinks used in final stage?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
d. Messenger cable and guys bonded properly?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐

	APPROVED	NOT APPLICABLE	REJECTED
12. Wood Poles			
a. Pole tagged or branded?	☐	☐	☐
b. Pole is installed to be plumb?	☐	☐	☐
c. Ground wire stapled to wood pole?	☐	☐	☐
d. Pole grounding electrode installed?	☐	☐	☐
13. Metal Poles			
a. Anchor bolt nuts torqued and rechecked after 48 hours?	☐	☐	☐
b. Pole is installed to be plumb?	☐	☐	☐
c. Identification tag attached?	☐	☐	☐
d. Pole grounding electrode installed?	☐	☐	☐
14. Fiber Optic Cable			
a. Cable ID markers installed at poles?	☐	☐	☐
b. Delineator markers installed?	☐	☐	☐
c. Snowshoes installed properly?	☐	☐	☐
d. Spare cable provided per plans?	☐	☐	☐
e. Splice enclosures secured, sealed, and weathertight?	☐	☐	☐
15. Conduits and Risers			
a. Riser assembles strapped properly?	☐	☐	☐
b. For fiber optic and coaxial cable, heat-shrink tubing seals top of riser?	☐	☐	☐
c. For other electrical cables, weatherhead seals top of riser?	☐	☐	☐
d. Mechanical seals installed for fiber optic cable at conduit ends?	☐	☐	☐
e. Moldable duct sealer used to seal other cables at conduit ends?	☐	☐	☐

	YES	NO
16. Has Part 2 of this checklist been completed?	☐	☐

INTERSECTION INSPECTION CHECK-LIST
NC PROJECT: _____

INTERSECTION LOCATION _____

SIGNAL INVENTORY NO. _____

PART II (to be completed by Division Traffic Engineering Office)

Inspected By: _____ **Date Inspected:** _____

17. Cabinet		
a. Is door seal weather-tight?	APPROVED ☐	REJECTED ☐
b. Is filter clean and replaceable?	APPROVED ☐	REJECTED ☐
c. Is conduit installed properly?	APPROVED ☐	REJECTED ☐
d. Cabinet wired neatly?	APPROVED ☐	REJECTED ☐
e. Wires labeled?	APPROVED ☐	REJECTED ☐
f. Documents in envelope in drawer?	APPROVED ☐	REJECTED ☐
g. Fan & thermostat operate properly?	APPROVED ☐	REJECTED ☐
h. Lights operational?	APPROVED ☐	REJECTED ☐
i. Loadswitches operational?	APPROVED ☐	REJECTED ☐
j. Flashers installed & operational?	APPROVED ☐	REJECTED ☐
k. Flash transfer relays installed?	APPROVED ☐	REJECTED ☐
l. Test switches call specified phase?	APPROVED ☐	REJECTED ☐
m. Police switches operate properly?	APPROVED ☐	REJECTED ☐
n. Ground isolated from neutral bus?	APPROVED ☐	REJECTED ☐
o. Metallic conduit bonded?	APPROVED ☐	REJECTED ☐

18. Electrical Service

a. Main bonding jumper installed? APPROVED ☐ REJECTED ☐

b. Other bonding installed properly? APPROVED ☐ REJECTED ☐

c. Breaker size correct? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

d. Ground rod resistance OK? (0.7 ohm reading is unacceptable) APPROVED ☐ REJECTED ☐

---

19. Inductive Loop Vehicle Detection

a. Resistance & megger readings OK? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

b. Detectors installed per plans? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

c. Detectors operating properly? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

---

20. Other Vehicle Detection

a. Detection zones per plans? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

b. Zones free from occlusion? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

c. Detection operating properly? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

---

21. Pedestrian Detection and Signals

a. Pushbuttons working properly? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

b. Signal heights correct? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

c. Audible signal working properly? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

d. Count-down timing correct? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

---

22. Controller Programming and Intersection Operation

a. General and phasing data verified? APPROVED ☐ REJECTED ☐

b. Coordination data verified? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

c. Preemption data verified? APPROVED ☐ NOT APPLICABLE ☐ REJECTED ☐

d. Indicate OASIS software version _____

e. Phasing & timing per plans? APPROVED ☐ REJECTED ☐

f. Startup sequence per plans?	APPROVED ☐		REJECTED ☐
g. Railroad Inspection completed?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
23. Conflict Monitor Programming			
a. Card programmed per plans?	APPROVED ☐		REJECTED ☐
b. Switches & jumpers set per plans?	APPROVED ☐		REJECTED ☐
24. Fiber Optic Splice Enclosure Installed Labeled and Secured?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
25. Fiber Optic Interface/ Splice Trays			
a. Splices acceptable and secured?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
b. Pigtails and jumpers labeled?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
26. Fiber Modems			
a. Mounted & operational?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
b. Cables labeled and secured?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
27. System Telemetry All devices communicate properly?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
28. Laptop Communicates with RS-232 Port on Controller and Conflict Monitor	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐
29. Removed and spare equipment has been returned to the Division?	APPROVED ☐	NOT APPLICABLE ☐	REJECTED ☐

Comments to be Addressed by Contractor

ITEM NO. Discrepancies Noted

Comments to be Addressed by NCDOT/CITY

ITEM NO. Discrepancies Noted

APPENDIX E – ANCHOR ROD TIGHTENING REQUIREMENTS FOR METAL POLES

Anchor Rod Nut Tightening Requirements for Metal Poles (9/4/08)

Prior to installation

Protect the anchor rod threads from damage prior to installation and during installation.

Prior to installation of the rods in the foundation, turn nuts onto and off the rods, well past the elevation of the bottom of the leveling nuts. Turn by the effort of one worker using an ordinary wrench without a cheater bar. Report to the Engineer thread damage requiring unusually large effort.

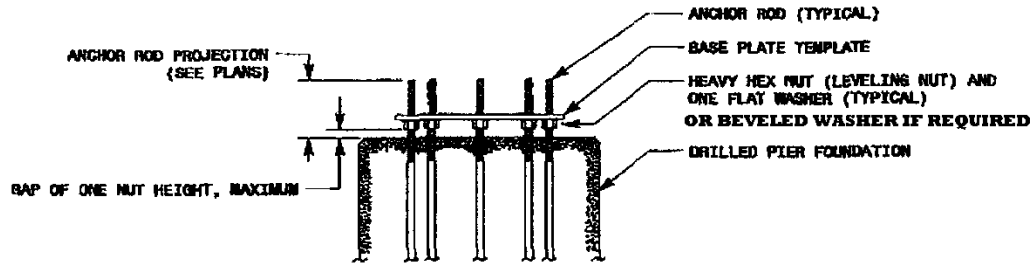
During installation

1. Place leveling nuts (bottom nuts) on the anchor rods.
2. Place leveling nut washers on top of the anchor rod leveling nuts.
3. Place a rigid template on top of the leveling nuts to check the level of the nuts. If the anchor nut and washer cannot be brought into firm contact with the template, then beveled washers shall be used.
4. Verify that the distance between the bottom of the leveling nut and the top of the concrete foundation is no more than one anchor rod diameter. If an upright is required to be back-raked, then the distance between the bottom of the leveling nut and the top of the concrete foundation should be no more than one anchor rod diameter, averaged over the anchor rod group.
5. Place the base plate and structural element to which it is attached. However, do not attach to the upright element, during tightening of the anchor nuts, cantilever beams or arms with span in excess of 10 feet. Luminaire arms and fixtures may be attached prior to standing the pole on the foundation.
6. Place top nut washers.
7. Do not use lock washers.
8. Lubricate threads and bearing surfaces of top nuts. Lubricant shall be beeswax, stick paraffin, or other approved lubricant.
9. Place top nuts. If the anchor nut and washer cannot be brought into firm contact with the base plate, then beveled washers shall be used.
10. Tighten top nuts to snug tight. A snug-tight condition is defined as the washer and nut being in full contact with the base plate, and the application of the full effort of a workman on a 12-inch wrench. Turn top nuts in increments following a star pattern (using at least two full tightening cycles).
11. To ensure proper pretensioning, after all top nuts have been brought to snug-tight condition, repeat the procedure on the leveling nuts. Turn leveling nuts in increments following a star pattern (using at least two full tightening cycles).
12. At this point, verify if beveled washers are required. Beveled washers are necessary under the leveling nut or top nut if any face of the base plate has a slope greater than 1:20 and / or any nut can not be brought into firm contact with the base plate.
13. Before further nut turning, mark the reference position of the nut in the snug-tight condition with a suitable marking (ink or paint that is not water-soluble). Mark on the corner at the intersection of two flats with a corresponding reference mark on the base plate at each nut. After tightening, verify the nut rotation.
14. Achieve pretensioning by turn-of-nut method. Turn the top nuts to 1/6 of a turn. Do so in a star pattern using at least two full-tightening cycles.
15. After installation, ensure that firm contact exists between the anchor rod nuts, washers, and base plate on any anchor rod installed.
16. For overhead sign assemblies: The span type truss or the cantilever truss may be placed on the uprights or attached to the upright at this time. For signal support structures: The span wires or mast arms may be attached to the upright at this time.

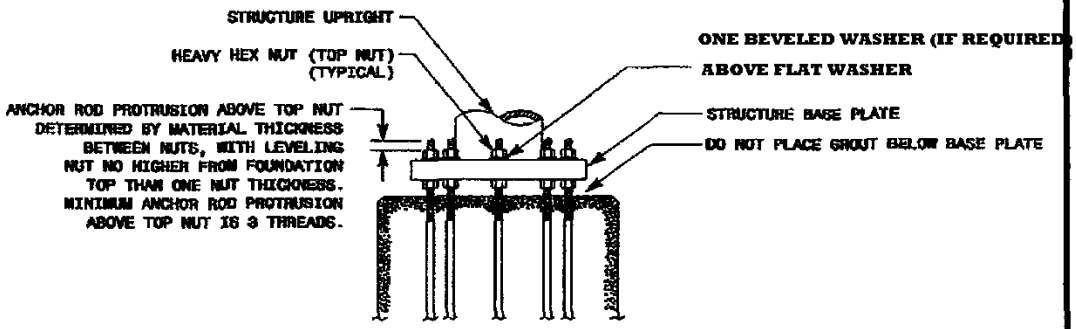
17. After a period of no less than 4 days, and no more than 2 weeks, and in the presence of the Engineer, use a torque wrench to verify that a torque at least equal to 600 foot-pounds is provided on each top nut. For cantilever structures, verify the torque after erection of the remainder of the structure and any heavy attachments to the structure.
18. If any top nut torque reveals less than 600 foot-pounds of effort is required to move the nut, then tighten the nut to no less than 600 foot-pounds.
19. Calibrate, at least annually, the torque indicator on the wrench used for tightening the nuts. Provide the Engineer a certification of such calibration.
20. Because inspection or re-tightening of the leveling nuts would be prevented, and to reduce moisture retention and associated corrosion, do not place grout under the base plate.

FOUNDATION BASE PLATE ANCHOR NUT AND HARDWARE INSTALLATION DETAILS

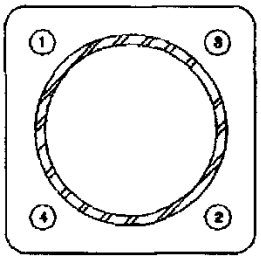
INSTALL LEVELING NUTS ON ANCHOR RODS



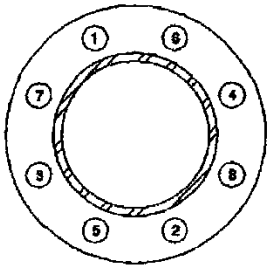
INSTALL STRUCTURE ON FOUNDATION



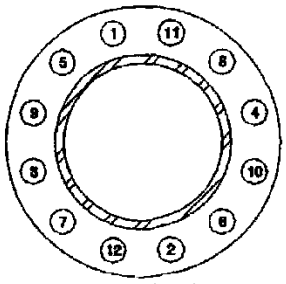
SEQUENCE OF TOP NUT SNUGGING, TOP NUT TIGHTENING, AND LEVELING AND TOP NUT TORQUE CHECKING



4 NUT PATTERN



8 NUT PATTERN



12 NUT PATTERN